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SUMMARY OF BESRL SURVEILLANCE RESEARCH

(Abstracted from BESRL Technical Research Report of same title--in press)

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Behavioral Science Research Laboratory

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SUMMARY OF BESRL SURVEILLANCE RESEARCH

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R. S. Andrews & M. A. Narva

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Research Laboratory

May 1969

Research Studies are special reports to military management. They
are usually prepared to meet requests for research results bearing on
specific management problems. A limited distribution is made--primarily
to the operating agencies directly involved.

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FOREWORD

Abstract

The SURVEILLANCE SYSTEMS research program of the U. S. Army Behavioral Science Research Laboratory has as its objective the production of scientific data bearing on the extraction of information from surveillance displays, and the efficient storage, retrieval, and transmission of this information within an advanced computerized image interpretation facility. Research results are used in future systems design and in the development of enhanced techniques for all phases of the interpretation process. Research is conducted under Army RDT&E Project 2Q6627044721, "Surveillance Systems: Ground Surveillance and Target Acquisition Interpreter Techniques," and 2Q662704A732, "Image Characteristics and Interpreter Performance," FY 1969 Work Program.

The ~~present publication~~ is report presents the major problem areas, the rationale of BESRL's approach to their solution, and the general course of research studies completed or in progress in each area of related problems. The research effort is currently organized into the following Work Units: ~~ABSTRACT~~
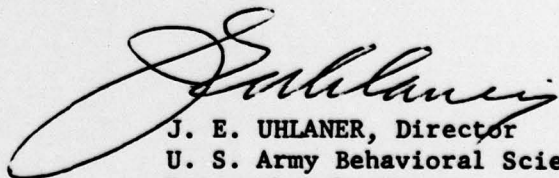
The Determination of Interpreter Techniques in a Surveillance Facility--INTERPRETER TECHNIQUES

Influence of Displays on Image Interpreter Performance--IMAGE INTERPRETATION DISPLAYS

Intelligence Information Processing Systems--INTELLIGENCE SYSTEMS

Information Processing in Advanced Image Interpretation Systems-- IMAGE SYSTEMS

BESRL research in surveillance systems is conducted as an in-house effort augmented by contracts with organizations selected as having unique capabilities and facilities for research in aerial surveillance. The experimentation is, in the main, performed in BESRL's Information Systems Laboratory.

J. E. UHLANER, Director
U. S. Army Behavioral Science
Research Laboratory

SUMMARY OF BESRL SURVEILLANCE RESEARCH

BRIEF

Requirements:

INTERPRETER TECHNIQUES. To develop methods and procedures which maximize the accuracy, completeness, and speed with which intelligence information is derived from imagery--photographs, infra-red, and radar.

IMAGE INTERPRETATION DISPLAYS. To determine how interpreter performance is affected by variations in the characteristics of the image-- magnification and image quality of photos, for example, and output of infrared and radar sensors; to specify techniques for accurate and speedy reporting of information; and to select or develop efficient procedures for change detection in comparing early and late cover.

IMAGE SYSTEMS. To integrate, evaluate, and improve advanced surveillance information processing systems through laboratory simulation and to develop effective techniques for team operations, data bank utilization, and control of imagery and information flow through the system.

INTELLIGENCE SYSTEMS. To increase the speed, accuracy, and completeness of field army intelligence processing in advanced computerized systems through research on man/machine functions, procedures, and information management.

Scope of the Present Publication:

Content of the present Research Study has been abstracted from a forth-coming BESRL Technical Research Report which summarizes in integrated fashion the rationale, broad objectives, and specific studies of the Surveillance Systems research programs conducted by the Support Systems Research Division of BESRL. Sketched very briefly in the present publication are the areas in which BESRL's manned systems experimentation has resulted in findings of interest to the Office, Chief of Research and Development, the Assistant Chief of Staff for Intelligence, and the U. S. Continental Army Command. Findings are applicable in optimizing performance of the human component in existing systems and in providing systems developers with information useful in design specifications for future systems. Included are the background discussion from the Report proper and a sampling of significant findings.

SUMMARY OF BESRL SURVEILLANCE RESEARCH
(Abstracted from BESRL Technical Research Report of the same title--in press)

BACKGROUND

Military decisions require an estimate of the enemy's strength and weaknesses, his manner of deployment, and his possible courses of action. To provide the needed information, many sources of intelligence must be utilized. One major source is aerial surveillance.

A significant intermediary output of aerial surveillance systems is the imagery generated by the various sensor systems flown to cover the terrain of interest. The image interpreter is the individual who transforms the information recorded on these images into intelligence information. Not too long ago, the interpreter's problem was restricted to the interpretation of black and white photographs. Nowadays, he must also extract information from images generated by the more exotic sensors such as infrared and radar, and what is more, the information must be rapidly produced. Moreover, with the every-increasing volume of imagery the new systems are able to generate, interpretation facilities are being inundated. Within this context, the focus is on the interpreter who must provide intelligence information meeting standards of acceptability. Based on the current state-of-the-art, it is expected that he will remain the key information transformation agent for some time to come.

It must be recognized that intelligence information is information and as such possesses characteristics of information. From the usability point of view, there are two major aspects of concern: the information content and certain information attributes. The content of the information is important because it relates directly to the requirements imposed on the surveillance system and directly on the interpreter. The information attributes provide the means for direct assessment of the information provided and thus can serve as the yardsticks for many comparisons. BESRL's manned systems research rests on the measurement of these attributes-- the accuracy and completeness of information and the speed with which it is generated.

Research in the area of surveillance systems must take into account a multiplicity of variables. There are, in fact, families of variables. For example, with respect to imagery, there is concern not only with type of image--photo infrared, and radar--but in photo imagery alone, there are vertical, oblique, and panoramic views. Photographs differ in scale and quality dimensions. They differ in content: They may depict different terrain (jungle, mountainous, swamp, desert); they may have been obtained under different weather conditions (cloud cover, snow, rain, sunny); they may show different degrees of enemy deployment in terms of target type and target numerosity. With respect to the interpreter, there are differences in ability, background, experience, and training. In requirements, there are differences as a function of echelon; for example, the commander of an

army is more concerned with the global picture than with knowing where the foxholes are. The company commander, for his part, is vitally concerned with where enemy obstacles are located. Within echelon there are different information requirements. The artillery officer is concerned with targeting information and therefore needs map coordinate data of sufficient precision that his artillery fire will include the target within the effective radius of the shell bursts. The engineering officer may wish to locate the best place to cross the river and to know the width of the river in order to plan for the requisite number of pontoons to span the river. The infantry officer whose forces are attacking may be concerned with the location of enemy ambush sites, their mine fields, etc.; in the defensive posture, he may need to know what kind of enemy forces will attack him and where they are most likely to attack. Superimposed on these requirements are the requirements that the information provided be accurate and complete, and that it be provided "yesterday." There are hosts of other factors that enter into the picture, such as display, equipment, and procedures.

A surveillance system built for the Army should be able to provide for the needs of all its users. With the multiplicity of variables that must be expected to have an effect on performance, system developers are confronted with numerous trade-off situations where decisions must be made whether to go one way or another. Data are desperately needed to assist in coming to logical conclusions.

In the area of intelligence information, BESRL research deals with at least three performance indices--accuracy, completeness, and timeliness of information. Results in terms of these indices are not always in the same direction. For example, BESRL research indicates that, while cumulative completeness increases as a function of time, cumulative accuracy decreases. Furthermore, accuracy can be emphasized at the expense of completeness and vice versa. There are various other trade-offs involving accuracy, completeness, and time that can be made. The problem concerning the man-machine interface resides in the nature of responses interpreters can and do make when they interpret an image. The interpreter may provide some correct detections and identifications. However, he may also fail to detect targets actually present, he may misidentify others, and under some conditions he may report targets that are not present. In other words, the information generated by interpreters possesses an attribute of fallibility.

The research presented in the present report is directed toward the improvement of information output of future surveillance, interpretation, and intelligence systems with fallout for current systems. Studies and findings should be of interest to the users of these systems (interpreters, G2 and G2 Air, commanders, etc.), system designers and engineers, the Intelligence School, and the Intelligence community at large.

APPROACH IN BESRL'S SURVEILLANCE SYSTEMS RESEARCH

The systems concept played a major role in the formulation of the research approach in the area of surveillance. A system can be thought of in terms of structure and function. It consists of personnel, equipment, materials, procedures, and environmental conditions. It receives input, performs operations, and provides output.

A system can also be thought of as consisting of subsystems, each with its own input, operations, and output, and each funneling its output into the larger system. System improvement can be achieved through the improvement of its subsystems and components. Assessment of subsystem effectiveness can be based on output measures of two types: 1) those based on output of the subsystems, and 2) those based on total system output. The ultimate determiner of subsystem effectiveness is, of course, its contribution to the total system. However, subsystem output may be useful in itself in many studies and at times may be the only measurable output available for assessment.

BESRL studies typically fall into two corresponding major categories, those concerned with assessing subsystems or subsystem components as entities in themselves and those concerned with the integration of these subsystems or components into a larger system for total system evaluation. The approach has been to analyze current systems and conceptualizations of future systems for the purpose of study design and execution. For either category of study, the research is planned so as to yield empirical performance data reflective of the maximum amount of operational realism compatible with appropriate experimental control. Most studies have as a basic element the presentation of tactical imagery to trained Army image interpreters, requiring them to perform their usual tasks of detection, identification, and mensuration. Their responses can then be scored for accuracy (percent of responses correct), completeness (percent of targets actually present in the imagery that are reported), and speed (number of targets or reports per unit of time). The study ramifications attendant to this basic element vary widely, depending on the number, type, and complexity of the variables being studied.

In the simplest case, little may be required beyond use of a light table and the assortment of manual aids found in the standard Photo-interpreter kit--tube magnifiers, slide rule, etc. In the more complex case, studies deal with a full-scale semiautomated computerized imagery interpretation system--interpreter, equipment, and procedures are totally interrelated. Any change in an element of such a system affects other elements in the system--and not necessarily in the desired or expected direction.

BESRL'S INFORMATION SYSTEMS LABORATORY

To accomplish the research in a timely and meaningful manner for such complex systems, which frequently are still in the conceptualization stage, an Information Systems Laboratory has been constructed within

the Support Systems Research Division of BESRL. This laboratory contains light tables, full frame magnification viewers, random access slide projectors, cathode ray tubes with keyboards, pushbutton matrices, and typewriter keyboards. More important, all equipment is on-line to BESRL's CDC 3300 computer[1] which is time-shared with the normal statistical processing of research data. The time-sharing is on a priority interrupt basis, the laboratory experimentation inputs/processing/outputs having priority.

A prime virtue of the Information Systems Laboratory is its flexibility. It not only permits empirical simulation of computerized systems which could not otherwise be studied, but also facilitates experimental control and data collection for studies where computerization is not requisite to the study itself. Ways in which the computer can facilitate such experiments include the following:

Computer automation provides precise control over an experiment. The experimenter may wish to present a stimulus for exactly six seconds; he may wish to present information to the subject only after certain criteria have been met; he may wish to pause when the subject has reached a certain point in the experiment. Automation guarantees that such procedures are followed exactly.

Automation provides detailed recording of events as specified by the experimenter. Every stimulus given to the subject and every response made by the subject can be recorded, including times of occurrence. The subject need not be aware that he is being timed; timing by stop watch, for example, can be a disturbing influence on the subject. The experimenter need not be physically present in cases where his presence might disturb the subject.

An automated experiment tends to be more uniform in quality. The biases that may arise from a particular person monitoring the performance of a group of subjects are minimized.

Instantaneous feedback can be provided the subject. Response-dependent experiments are very difficult to perform manually if the feedback depends on the responses in a complicated manner. Randomized stimuli that are not possible with manual techniques can be provided when automation is used.

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[1] Commercial designations are given for information only; their mention does not constitute indorsement by BESRL or by the Army.

BRIEF REVIEW OF BESRL'S SURVEILLANCE SYSTEMS RESEARCH

Research studies completed or in progress are grouped in three categories: those concerned primarily with specific tasks and functions in and of themselves without immediate regard for systems use, those concerned with the display requirements for accomplishing actual or conceptualized tasks, and those requiring a systems context for execution because of concern with the totality of system performance as well and the separate and interactive contribution of the various subsystems and elements.

RESEARCH ON INTERPRETER TECHNIQUES

A number of aspects of interpretation have been subjected to investigation, notably problems of trade-offs among accuracy, completeness, and time, control of imagery viewing procedures, methods for increasing the proficiency level of interpreters, and the interpretation of infrared and radar imagery.

Research concerns interpreter activities with emphasis on the cues and signatures for tactical targets and definition of the interpreter's job in such functions as screening, interpretation, target location, plotting, and mensuration. BESRL findings indicate that many factors affect performance; the _imagery_, its content, quality, and scale; the _requirements_ imposed on the interpreter with respect both to content and the attributes of accuracy, completeness, and speed; the _man_, his ability, background, and experience; and the _method_ _of_ _displaying_ the imagery.

In many instances, the limits of the interpreter's abilities are taxed by the tasks imposed, as when he is required to derive information from poor quality imagery or from infrared and radar. Image interpretability and the nature of interpreter errors are prime areas of investigation. Studies in these areas permit determination of threshold conditions and diagnosis of difficulties and provide direction on how best to attain improvement in performance.

Other research studies indicate the importance of establishing optimal viewing time, since identification accuracy decreases as time spent in interpretation increases. Findings on plotting and target location have indicated that accuracy of the flight trace provided by the pilot of the imagery gathering mission has an effect on plotting performance. For screening, it was found that interpreters could report both priority and non-priority targets without significant increase in interpretation time and with little loss in the completeness and accuracy with which priority targets were identified. Good quality imagery at scales of 1:2000 viewed at a rate of six seconds per frame was screened with 86 percent accuracy; at .8 second per frame, accuracy was 75 percent. Another study identified potentially useful techniques to speed up imagery screening by means of eye movement and scoring techniques. For change detection, a computer method which relies on a check of new against old reports was better than the conventional comparative cover interpretation

method. For selected sensors (infrared and radar), cues and signatures have been identified and consolidated into potentially useful techniques for improved interpretation. A technique for reading the binary code numeric information of the matrix data block (including coordinate location) has been developed. The technique is easily learned and provides an accuracy rate of 98 per cent for reading the block.

IMAGE INTERPRETATION DISPLAYS

Research findings from studies on displays provide information on display requirements based on interpreter needs. These findings are of more immediate use to those concerned with the development of interpretation equipment and systems--system designers and engineers in particular. The nature of this work implies the need for discrete studies, since display requirements are of necessity tied to specific requirements imposed on interpreters under prevailing conditions.

Among previous BESRL research efforts, it was found that stereo viewing does not, in general, improve interpreter performance. It was further found that the time required for screening or interpreting the overlapping photography required for stereo viewing was considerably greater than for non-overlapping imagery, and with no additional benefits of increased accuracy or completeness. In a different study, it was found that interpretation performance is equally good with positive or negative transparencies, implying that under some circumstances at least the extra step of providing positives could be eliminated. Another study found that "error keys"--photographic references depicting conditions that often give rise to false alarms (inventive errors)--reduce appreciably the number of such reports. A study on the characteristics of photo keys revealed no advantage to the use of photos as opposed to schematics or to the use of vertical as opposed to oblique views. Use of small-scale illustrations, however, did prove detrimental in that additional time was required to magnify the views. These results must be considered tentative at this time because of the limited nature of the study.

In change detection, research findings indicate that the larger the difference in photo scale and/or orientation of the early and late cover, the lower the accuracy and completeness of change detection and the longer the response time. In addition, alternative target entry and correction procedures using such input/output devices as teletypewriters, cathode ray tubes with associated typewriter, and fixed-response keyboards interfaced in the Information Systems Laboratory with a CDC digital computer were studied.

SYSTEMS STUDIES

BESRL's image and intelligence system studies are concerned with a number of different facets relating to system development and system use. They serve the purposes of integrating findings from many relevant efforts,

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of conceptualizing and evaluating system alternatives, and of conceptualizing and testing various aspects of system and computer use to maximize the capability of the system. The underlying expectation of some of these efforts is that future interpretation facilities will have computers, and that these computers can serve many more purposes than the mere storage and retrieval of data and the computation required for obtaining map coordinates. Within this area, BESRL is conducting research to develop and use a systems measurement methodology, developing procedures by means of which the computer can assist man in the decision process, and determining how best to use computerized interpretation facilities for maintenance or improvement of interpreter proficiency.

The research is realized through laboratory simulation and the development of effective techniques for improving team operations, data bank utilization, and control of imagery and report flow through the system. A simulated advanced image interpretation facility has been developed in BESRL's Information Systems Laboratory as a means of exercising a standard measurement package for assessing the performance of alternative concepts and system configurations--an effort but recently completed. The package includes all materials and instructions necessary for evaluating a variety of tactical image interpretation facilities. On the basis of such systems evaluation, modifications and improvements can be introduced.

Emphasis is on the development of automated data handling techniques to assist the decision process. Studies have been conducted on problems of controlling input to the system, screening information for relevance, transforming information into computer-acceptable format, inputting data, displaying information, obtaining valid assessments of information credibility, determining the critical functions that must be performed by men and those that can be automated wholly or in part, and integrating diverse information into intelligence reports and disseminating information.

BESRL RESEARCH PUBLICATIONS ON THE SURVEILLANCE SYSTEMS PROGRAMS

TECHNICAL RESEARCH REPORTS

TRR 1129. Sadacca, R., H. Martinek, and A. I. Schwartz. Image interpretation task--Status report. 30 June 1962.

TRR 1143. Martinek, Harold, Robert Sadacca, and Laverne K. Burke. Development of a selection battery for Army image interpreters. October 1965.

TRR 1150. Brainard, Robert W., Louis J. Lopez, and George N. Ornstein. North American Aviation, Inc., and Robert Sadacca, BESRL. Development and evaluation of a catalog technique for measuring image quality. August 1966.

TRR 1151. Doten, G. W., and John T. Cockrell, System Development Corp., and Robert Sadacca, BESRL. The use of teams in image interpretation: Information exchange, confidence, and resolving disagreements. October 1966.

TECHNICAL RESEARCH NOTES

TRN 114. Zeidner, J., R. Sadacca, and A. I. Schwartz. Human factors studies in image interpretation: The value of stereoscopic viewing. June 1961.

TRN 117. Sadacca, R., A. Castelnovo, and J. Ranes. Human factors studies in image interpretation: The impact of intelligence information furnished interpreters. June 1961.

TRN 120. Sadacca, R., J. Ranes, and A. I. Schwartz. Human factors studies in image interpretation: Vertical and oblique photos. December 1961.

TRN 122. Birnbaum, A. H. Human factors research in image systems--Status report. 30 June 1962.

TRN 136. Sadacca, R. and A. I. Schwartz. Psychophysical aspects of image quality--Exploratory study. September 1963.

TRN 153. Martinek, Harold and Robert Sadacca. Error keys as reference aids in image interpretation. June 1965.

TRN 164. Bolin, Stanley F., Robert Sadacca, and Harold Martinek. Team procedures in image interpretation. June 1965.

TECHNICAL RESEARCH NOTES (cont'd)

TRN 165. Thomas, James A. and Robert Sadacca. Ability of image interpreters to adapt output to varying requirements for completeness and accuracy. December 1965.

TRN 166 (C). Martinek, Harold and James A. Thomas. The effects of image resolution and lighting orientation on intelligence (Unclassified Title). February 1966. CONFIDENTIAL

TRN 169. Laymon, Richard S., System Development Corp. Study of two image interpreter map displays: Chip versus hard copy. May 1966.

TRN 170. Root, Robert T., BESRL, and Douglas Waugh, Kyra Hewitt, and James Donoghue, IBM Corp. An analysis of interpreter-computer reporting techniques. June 1966.

TRN 173. Nelson, Arthur, Kenneth McClure, and J. Pohlgreen, IBM Corp., and Robert Sadacca, BESRL. Organization and presentation of image interpreter reference and auxiliary information. June 1966.

TRN 174. Birnbaum, Abraham H. Exploratory study in interpretation of vertical and high oblique photographs. June 1966.

TRN 176. Laymon, Richard S., System Development Corp. An experimental study of two methods of indexing tactical imagery. July 1966.

TRN 179. Mathers, Boyd L., System Development Corp. Relative effectiveness of different viewing devices for photo interpretation. November 1966.

TRN 180. Willmorth, N. E., System Development Corp. Influence of overlap on speed and accuracy in screening imagery. February 1967.

TRN 182. Willmorth, N. E., System Development Corp., and Abraham H. Birnbaum, BESRL. Influence of screening and overlapping imagery on speed and accuracy of photo interpretation. April 1967.

TRN 183. Levy, Girard W., Leonard A. Evans, and John M. Humes, North American Aviation, Inc., and Robert Sadacca, BEARL. Probability indexes of image interpreter performance: Development and evaluation. June 1967.

TRN 184. McKendry, James H., and Paul C. Harrison, HRB-Singer, Inc., and A. Birnbaum and Robert Sadacca, BESRL. Estimating the value of surveillance information using error cost matrices. June 1967.

TRN 185. Hansen, O. K., K. R. Colson, and L. Vettese, Nortronics Div. of Northrop Corp., and H. C. Strasel, BESRL. Method for developing a laboratory model of an image interpretation system (Unclassified Title). June 1967. CONFIDENTIAL

TECHNICAL RESEARCH NOTES (cont'd)

TRN 186. Laymon, Richard S., System Development Corp. Evaluation of three computer-compatible procedures for using image interpreter keys. June 1967.

TRN 187. Thomas, James A. and Robert Sadacca. Impact of feedback on accuracy of confidence levels assigned by interpreters. June 1967.

TRN 189. Thomas, James A. and Robert Sadacca. Rapid screening of tactical imagery as a function of display time. June 1967.

TRN 195. Cockrell, J. T. and Robert Sadacca. Maintaining image interpreter proficiency through team consensus feedback. April 1968.

TRN 200. Baker, James D., BESRL, and James M. McKendry and Douglas J. Mace, HRB-Singer, Inc. Certitude judgments in an operational environment. November 1968.

RESEARCH STUDIES

RS 59-1. Zeidner, J. and A. H. Birnbaum. Survey of psychological factors in image interpretation. February 1959.

RS 60-3. Zeidner, J. and R. Sadacca. Research on human factors in image interpreter systems. July 1960.

RS 66-4. Bigelow, George F. Human Factors problems in the development and use of image interpretation keys. May 1966.

RS 68-3. Bigelow, George F. Contents of BESRL aerial surveillance film library--1 January 1968. May 1968.

OTHER

Martinek, Harold and George F. Bigelow, BESRL and Robert C. Jorgensen, North American Rockwell Corp. PT 4708, Reference manual: An image interpretation key to U. S. Army Tents (Pole, frame, and air-supported). September 1968.